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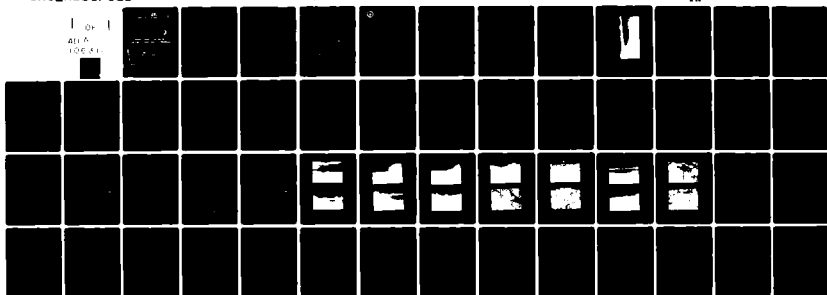
NATIONAL DAM SAFETY PROGRAM. ROTH FARMS LAKE DAM (MO 20434). OS--ETC(U)

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ROTH FARM LANE DAM

CASS COUNTY, MISSOURI

NO 20434



PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

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**United States Army
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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

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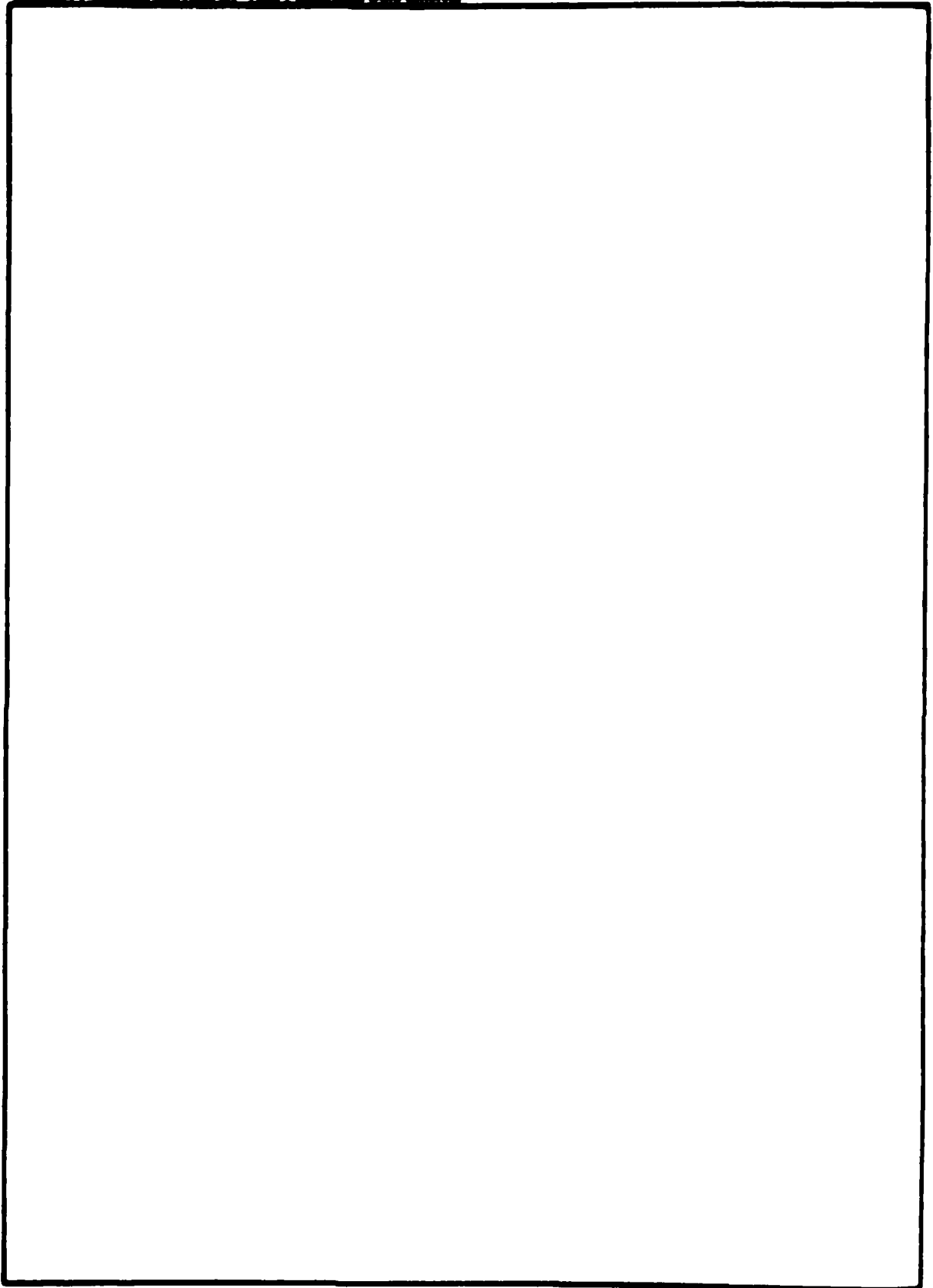
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21. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams			
22. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.			

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ROTH FARMS LAKE DAM
CASS COUNTY, MISSOURI
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PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



United States Army
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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT. ST. LOUIS

FOR: STATE OF MISSOURI

JUNE 1980



DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

LMSD-PD

SUBJECT: Roth Farms Lake Dam, MO. I.D. No. 20434
Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Roth Farms Lake Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

- a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.
- b. Overtopping of the dam could result in failure of the dam.
- c. Dam failure significantly increases the hazard to loss of life downstream.

SIGNED

25 SEP 1980

SUBMITTED BY:

Chief, Engineering Division

Date

SIGNED

25 SEP 1980

APPROVED BY:

Colonel, CE, District Engineer

Date

ROTH FARMS LAKE DAM
CASS COUNTY, MISSOURI

MISSOURI INVENTORY NO. 20434

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF
ST. LOUIS DISTRICT CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

JUNE 1980

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Roth Farms Lake
State Located	Missouri
County Located	Cass County
Stream	Tributary to Camp Branch Creek
Date of Inspection	19 June 1980

Roth Farms Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten lives and property. The estimated damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are four dwellings, two barns, four buildings, two light duty roads and one railroad.

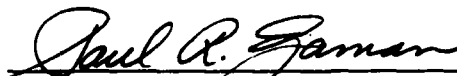
Our inspection and evaluation indicates the spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillways will not pass the probable maximum flood without overtopping but will pass 20 percent of the probable maximum flood. The spillways will pass the one percent probability flood flow (100-year flood). The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the presence of residences within the first one-half mile of the downstream hazard zone, the spillway design flood should be 100 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions which are reasonably possible in the region.

Based on visual observations, this dam appears to be in good condition. Deficiencies visually observed by the inspection team were cracks on the crest of the dam; erosion on the crest, upstream slope, and downstream slope; an animal burrow on the downstream slope; the absence of a trash rack on the principal spillway pipe inlet; the absence of riprap on the upstream slope, and the undersized principal spillway pipe. Discharges from the spillways may endanger the integrity of the dam through toe erosion. Seepage and stability analyses required by the guidelines were not available.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.



Paul B. MacRoberts
Missouri E-15374



Paul R. Zaman, PE
Illinois 62-29261



Harry L. Callahan, Partner
Black & Veatch



OVERVIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
ROTH FARMS LAKE DAM

TABLE OF CONTENTS

<u>Paragraph No.</u>	<u>Title</u>	<u>Page No.</u>
SECTION 1 - PROJECT INFORMATION		
1.1	General	1
1.2	Description of Project	1
1.3	Pertinent Data	2
SECTION 2 - ENGINEERING DATA		
2.1	Design	5
2.2	Construction	5
2.3	Operation	5
2.4	Geology	5
2.5	Evaluation	5
SECTION 3 - VISUAL INSPECTION		
3.1	Findings	6
3.2	Evaluation	7
SECTION 4 - OPERATIONAL PROCEDURES		
4.1	Procedures	8
4.2	Maintenance of Dam	8
4.3	Maintenance of Operating Facilities	8
4.4	Description of Any Warning System in Effect	8
4.5	Evaluation	8
SECTION 5 - HYDRAULIC/HYDROLOGIC		
5.1	Evaluation of Features	9
SECTION 6 - STRUCTURAL STABILITY		
6.1	Evaluation of Structural Stability	11

TABLE OF CONTENTS (Cont'd)

<u>Paragraph No.</u>	<u>Title</u>	<u>Page No.</u>
SECTION 7 - ASSESSMENT/REMEDIAL MEASURES		
7.1	Dam Assessment	12
7.2	Remedial Measures	12

LIST OF PLATES

<u>Plate No.</u>	<u>Title</u>
1	Location Map
2	Vicinity Topography
3	Dam Plan
4	Dam Cross Section
5	Emergency Spillway Profile
6	Photo Index

LIST OF PHOTOGRAPHS

<u>Photo No.</u>	<u>Title</u>
1	Crest of Dam at Left Wing
2	Crest of Dam at Center Section
3	Upstream Face of Dam
4	Upstream Face of Dam at Left Wing
5	Upstream Face of Dam
6	Downstream Face of Dam Looking East
7	Downstream Face of Dam Looking West

TABLE OF CONTENTS (Cont'd)

<u>Photo No.</u>	<u>Title</u>
8	Principal Spillway Inlet
9	Erosion Near Principal Spillway Inlet
10	Erosion Near Principal Spillway Outlet
11	Emergency Spillway Looking Upstream
12	Emergency Spillway Looking Downstream
13	Cracking on Dam Crest
14	Animal Burrow on Dam Crest

APPENDIX

Appendix A - Hydrologic and Hydraulic Analyses

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Roth Farms Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure located in the valley of a tributary to Camp Branch Creek (Plate 1). The watershed is an area of flat lands containing about 80% crop land, 15% grassland and 5% timber (Plate 2). The dam is approximately 1,150 feet long along the crest and 22 feet high. The dam crest is 9 feet wide. The downstream face of the dam has a nonuniform slope from the crest to the valley floor below.

(2) The principal spillway from the lake is an uncontrolled 6-inch steel pipe installed in the embankment. There is an 18-inch steel, bowl-shaped drop structure, about 10 inches deep, at the upstream end. Flow through the pipe passes through a culvert underneath Missouri Highway 2 to the natural streambed. The emergency spillway consists of a low, grass-lined area at the left abutment. Discharge over the crest of the emergency spillway flows downstream to a channel at the embankment toe along Missouri Highway 2.

(3) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in east-central Cass County, Missouri. The location is shown on Plate 1. The lake formed by the dam

is an area shown on the United States Geological Survey 7 1/2 minute series quadrangle map for East Lynne, Missouri in Section 4 of Tash. R306

c. Size Classification Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification The hazard classification assigned by the Corps of Engineers for this dam is as follows. The Roth Farms Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Roth Farms Lake Dam the estimated flood damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are four dwellings, two barns, four buildings, two light duty roads and one railroad. Contents of the downstream hazard zone were verified by the inspection team.

e. Ownership The dam is owned by Mr. Dwight Roth of the Roth Hereford Farms, Route No. 1, P.O. Box 510, Harrisonville, Missouri 64701, Telephone 816-869-3560.

f. Purpose of Dam The dam forms a 22-acre lake used as an irrigation water supply.

g. Design and Construction History The dam was designed by the Soil Conservation Service. The construction of the dam in 1975 was done by Wayne Scott and Sons of Garden City, Missouri.

h. Normal Operating Procedure The lake is pumped down for irrigation several feet each year. The lake level normally remains below the principal spillway pipe invert. The lake level is also controlled by rainfall, runoff, evaporation, and transpiration.

1.3 PERTINENT DATA

a. Drainage Area - 107 acres

b. Discharge at Damsite

(1) Normal discharge at the damsite is through an uncontrolled 6-inch steel outlet pipe.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation
800 cfs (Probable Maximum Flood Pool El 880.7)

c. Elevation (Feet above m.s.l.)

- (1) Top of dam - 879.2 (see Plate 3)
- (2) Emergency spillway crest - 878.0
- (3) Principal spillway pipe invert - 877.6
- (4) Streambed at toe of dam - 857.9
- (5) Maximum tailwater - Unknown

d. Reservoir

(1) Length of maximum pool - 2,000 feet * (Probable maximum flood pool level)

(2) Length of normal pool - 1,800 feet * (Principal spillway pipe invert)

e. Storage (Acre-feet)

- (1) Top of dam - 15'
- (2) Emergency spillway crest - 128
- (3) Principal spillway pipe invert - 120
- (4) Design surge - Not available

f. Reservoir Surface (Acres)

- (1) Top of dam - 25.8
- (2) Emergency spillway crest - 22.6
- (3) Principal spillway pipe invert - 21.6

g. Dam

- (1) Type - Earth embankment
- (2) Length - 1,150 feet

- (3) Height - 22 feet \pm
- (4) Top width - 9 feet
- (5) Side slopes - upstream face varies from 1.0 V on 5.0 H to 1.0 V on 13.0 H, downstream face varies from 1.0 V on 1.1 H to 1.0 V on 3.9 H (see Plate 4).

- (6) Zoning - Unknown.
- (7) Impervious core - Unknown.
- (8) Cutoff - Unknown.
- (9) Grout curtain - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Principal Spillway.

(1) Type - 6-inch steel pipe with an 18-inch steel, bowl-shaped drop structure.

- (2) Inlet invert elevation - 877.6 feet m.s.l.
- (3) Outlet invert elevation - 859 feet m.s.l. (approximated)
- (4) Gates - None.
- (5) Upstream channel - Clear of trees and debris.

(6) Downstream channel - Through a culvert underneath Missouri Highway 2 to the streambed.

j. Emergency Spillway.

- (1) Type - Grass open channel.
- (2) Width of channel - 55 feet.
- (3) Emergency spillway crest - 878.0
- (4) Gates - None.
- (5) Upstream channel - Clear of trees and debris.
- (6) Downstream channel - Along left side of dam to a channel at the toe along Missouri Highway 2.

k. Regulating Outlets - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The dam was designed by the Soil Conservation Service. No design data were available.

2.2 CONSTRUCTION

Construction records were unavailable, however, the dam was constructed in 1975 by Wayne Scott and Sons, Garden City, Missouri.

2.3 OPERATION

Documentation of past floods was not available.

2.4 GEOLOGY

The site of the dam and reservoir is located in a broad shallow valley. The dam impounds a small intermittent tributary to Camp Branch Creek.

The soils of the area consist of the Kenoma and Haig soil series. The Kenoma series consists of deep, moderately well-drained soils formed in old alluvium on uplands. The depth of rock is greater than five feet. The soils are classified for engineering purposes as low-plastic silt (ML), low or high-plastic clay (CL or CH) and low-plastic silty clay or clayey silt (ML-CL). The Haig series consists of poorly drained soils formed in loess on uplands. Rock is normally greater than five feet in depth. The soils are classified for engineering purposes as low or high-plastic clay (CL or CH).

The bedrock in the area of the dam and reservoir consists of the Marmaton Group. The Marmaton Group is composed of interbedded limestone, sandstone, shale and coal.

2.5 EVALUATION

- a. Availability. No engineering data could be obtained.
- b. Adequacy. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.
- c. Validity. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Roth Farms Lake Dam was made on 19 June 1980. The inspection team consisted of Paul MacRoberts, team leader; Gary Van Riessen, geotechnical engineer; Bob Pinker, geologist; Andy Dywan, civil engineer; Al Reif, civil engineer; and Russ Burnham, civil engineer. The dam is in good condition. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following conditions at the dam. Shrinkage cracks, up to one inch wide, were observed on the crest of the embankment. Most of the cracks run parallel to the dam axis. The upstream slope of the embankment has irregularities at the water line due to wave action. The embankment has minor stability problems, which are unlikely to lead to failure. There was no evidence of seepage in the embankment, foundation or abutments. No toe drains or relief wells were observed. The dam crest and slopes had a protective grass cover but no riprap. The grass on the embankment is mowed and fertilized. There are no trees on the embankment. Some erosion of the silty clay (CL) embankment material was observed including several deep ruts on the dam crest. Erosion was also observed on the upstream slope and on the downstream slope. One animal burrow was located on the downstream slope near the crest at the middle of the dam. No sliding, sloughing, settlement, or sinkholes were observed. There was no evidence to indicate that the embankment has ever been overtopped.

c. Appurtenant Structures. The inspection team observed the following items pertaining to the appurtenant structures. The principal spillway pipe was unobservable except for the inlet. No evidence of leakage was noted into, out of or around the principal spillway pipe. Some erosion of material was observed around both the inlet and the outlet end of the principal spillway pipe. The principal spillway lacks protection against debris and trash. The emergency spillway is constructed in CL material. It contains no erosion or obstructions to flow and is considered to be in good condition. The spillway curves near its discharge end to a flat area. The channel is small and an abnormally large spillway discharge could erode the embankment. Discharges from the spillways may endanger the integrity of the dam through toe erosion. There was no development in the emergency spillway area which could suffer damage due to flow through the spillway.

d. Geology. The soil in the area of the dam and reservoir consists of silty clay (CL) formed in loess and alluvium. No outcrops of rock

were observed in the area. It is believed that the abutments and foundation consist of silty clay (CL) overlying shale, limestone or sandstone bedrock of the Marmaton Group. Samples of the embankment material were taken near the center of the dam, at the break in slope of the crest and downstream slope. These samples were visually classified as silty clay (CL). Based on the samples and visual observations, it is believed that the embankment material consists of silty clay (CL).

e. Reservoir Area. No slumps or slides of the reservoir banks were observed. There is some minor lake siltation along the upstream face of the embankment. A large quantity of brush and trees lies in the upper end of the lake.

f. Downstream Channel. Flow from of the principal spillway outlet pipe passes through a culvert underneath Missouri Highway 2 to the natural streambed.

3.2 EVALUATION

The various deficiencies observed at the time of the inspection are not believed to represent an immediate safety hazard. They do, however, warrant monitoring and control. The cracks on the crest will increase the potential for sloughing or sliding of slope segments as additional water enters the cracks. The absence of riprap on the face of the dam has resulted in wave action erosion of the embankment. If not corrected, wave action will continue to erode the embankment and could lead to slope stability problems. The capacity of the principal spillway pipe should be increased. The lack of protection of the principal spillway from debris and trash can result in obstruction of the principal spillway. Toe erosion caused by discharges from the spillways may endanger the integrity of the dam. Animal burrows can lead to deterioration of the embankment from water entering these voids. If animal burrowing is allowed to go unchecked, serious damage to the embankment may occur.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, releases (pumped) for irrigation water supply, evaporation, and transpiration. Due to the pumping, the water level is usually below the principal spillway invert elevation.

4.2 MAINTENANCE OF DAM

The existing maintenance program includes fertilizing and mowing the grass on the crest and slopes of the embankment.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities were observed.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing warning system or preplanned scheme for alerting downstream residents for this dam.

4.5 EVALUATION

The maintenance program should continue to include mowing the grass cover on the embankment in order to discourage animal burrowing.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data pertaining to hydrology and hydraulics were unavailable.

b. Experience Data. The drainage area and lake surface area are developed from USGS East Lynne Quadrangle Map. The dam layout is from a survey made during the inspection.

c. Visual Observations.

(1) The principal spillway appears to be in good condition. The lake level at the time of the inspection was below the inlet level and there was no flow through the pipe. Only the inlet end was observed. The spillway pipe discharges into a natural channel. There were no obstructions to flow in the downstream channel.

(2) The emergency spillway channel is in good condition with no evidence of erosion at the time of the inspection.

(3) Discharges from the spillways may endanger the integrity of the dam through toe erosion.

d. Overtopping Potential. The spillways will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillways will pass 20 percent of the probable maximum flood without overtopping the dam. The spillways will pass the one percent probability flood estimated to have a peak outflow of 66 cfs developed by a 24-hour, one percent probability rainfall. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the presence of residences in the first one-half mile of the downstream hazard zone, the appropriate spillway design flood should be 100 percent of the probable maximum flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 550 cfs of the total discharge from the reservoir of 1,350 cfs. The estimated duration of overtopping is 6.2 hours with a maximum height of 1.5 feet. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 50 cfs of the total discharge from the reservoir of 460 cfs. The estimated duration of overtopping is 3.4 hours with a maximum height of 0.7 feet. The embankment may be jeopardized by overtopping for these periods of time.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately two miles downstream of the dam. Four dwellings, two barns, four buildings, two light duty roads and one railroad could be severely damaged and lives could be lost should failure of the dam occur. There does not appear to be any flood plain regulation or other constraints in force to limit future downstream development. Contents of the downstream hazard zone were verified by the inspection team.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.lb.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. No operational records exist.

d. Postconstruction Changes. No changes have been made since completion of the dam.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone. The seismic stability of an earth dam is dependent upon a number of factors: embankment and foundation material classifications and shear strengths; abutment materials, conditions, and strengths; embankment zoning; and embankment geometry.

Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the visual inspection by the inspection team should be monitored and/or controlled. These are cracks on the crest of the embankment, the absence of riprap on the upstream slope, and the undersized principal spillway pipe. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the lack of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. A program should be developed as soon as possible to monitor at regular intervals the deficiencies described in this report. The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. The item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam nor does it identify any serious dangers which would require a Phase II investigation. However, the additional analyses noted in paragraph 2.5b are necessary for compliance with the guidelines.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. The emergency spillway size and/or height of dam would need to be increased or the lake level would need to be lowered to increase available flood storage in order to pass the spillway design flood. The emergency spillway should be protected to prevent erosion.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures should be carried out under the direction of an engineer experienced in the design, construction, and inspection of dams:

(1) Riprap should be placed on the upstream face of the dam at the normal lake level to prevent erosion of the embankment material

(2) The cracking and ruts along the crest of the dam and erosion on the upstream and downstream slopes should be repaired.

(3) The capacity of the principal spillway should be increased

(4) The existing maintenance program should be continued and should include measures to control burrowing animals.

(5) A trash rack should be added to the principal spillway inlet

(6) Seepage and stability analyses should be performed.

(7) Measures should be implemented to prevent erosion of embankment material at the toe due to discharges from the spillways.

(8) A detailed inspection of the dam should be made periodically. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increase.

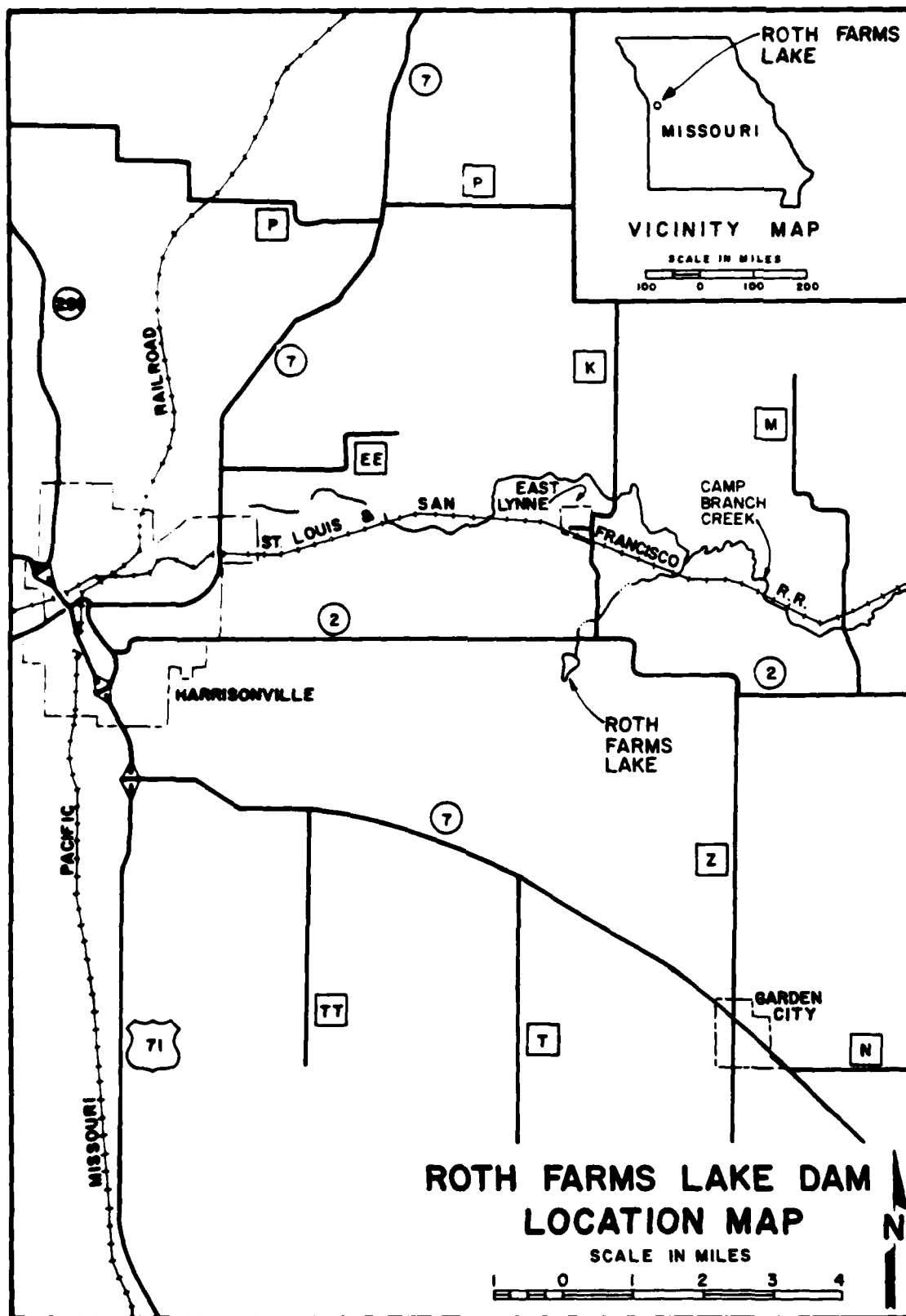


PLATE I

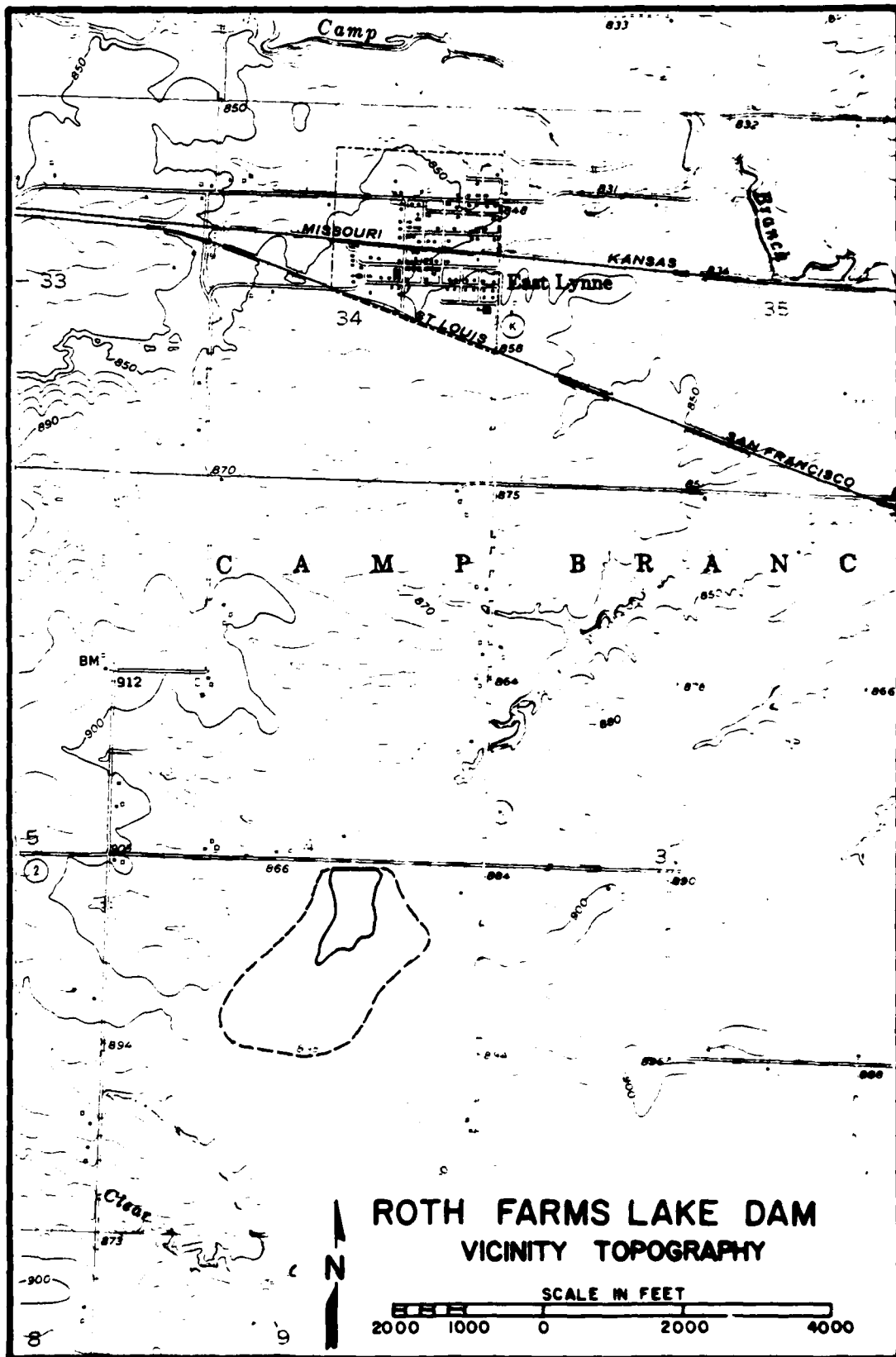


PLATE 2

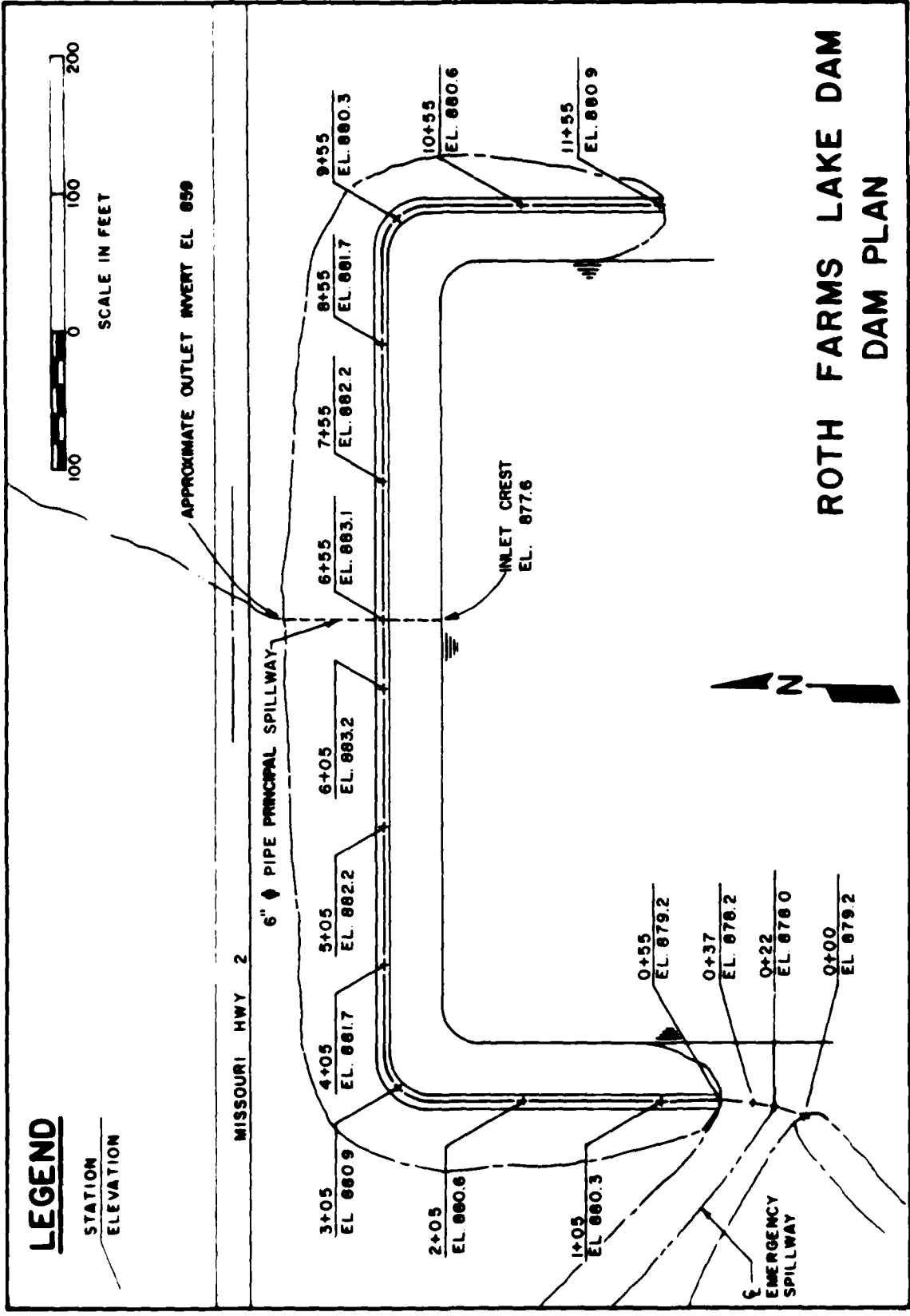
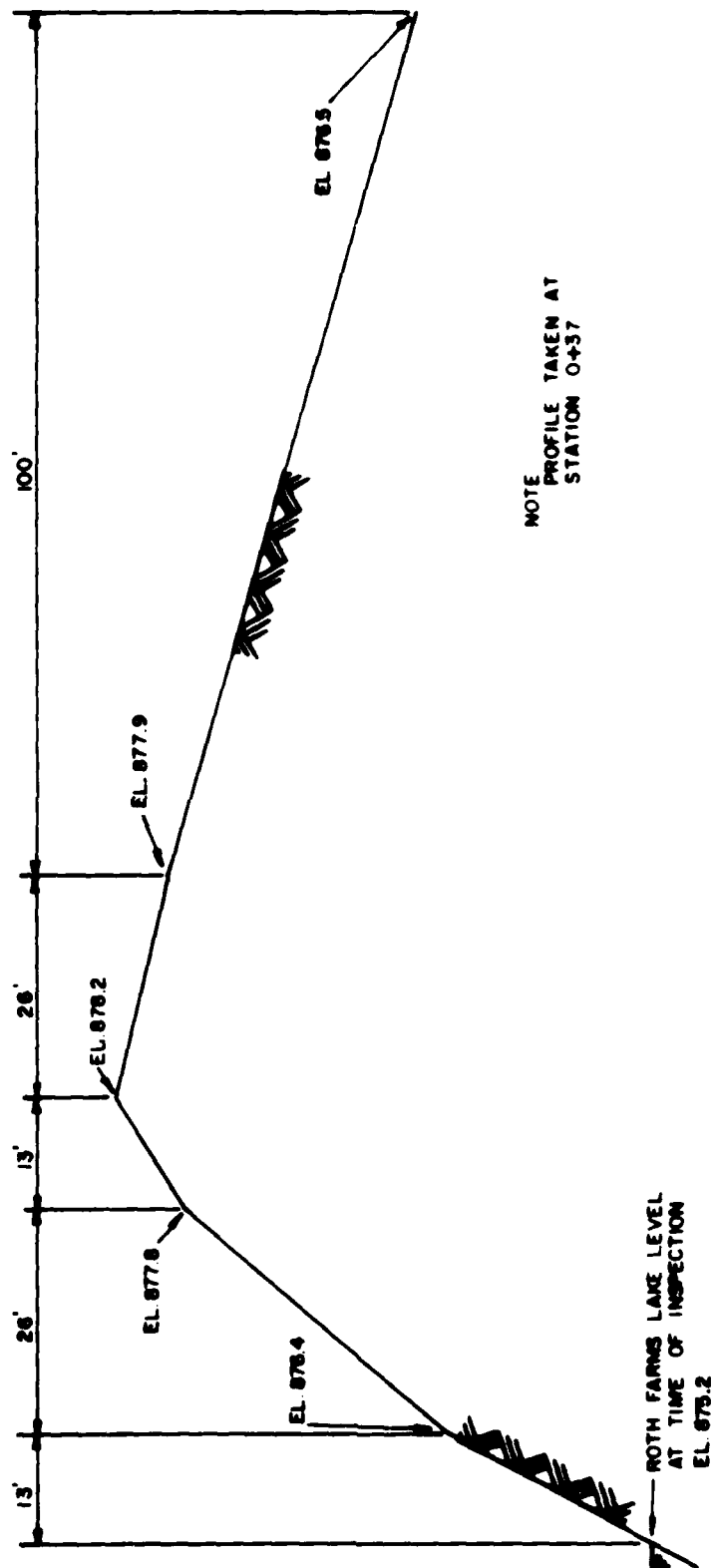
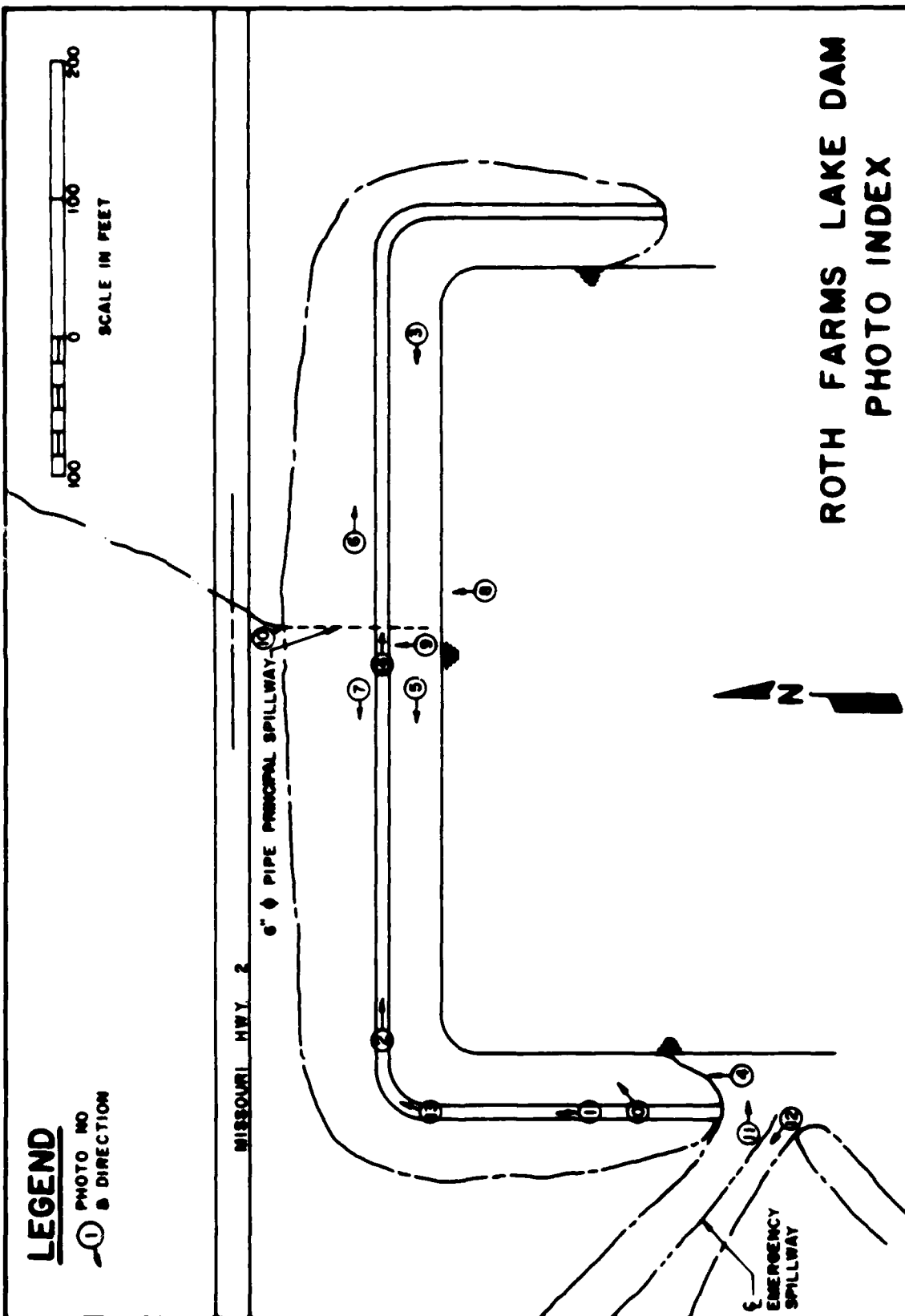


PLATE 3

ROTH FARMS LAKE DAM EMERGENCY SPILLWAY PROFILE

NOTE
PROFILE TAKEN AT
STATION 0+37





**ROTH FARMS LAKE DAM
PHOTO INDEX**

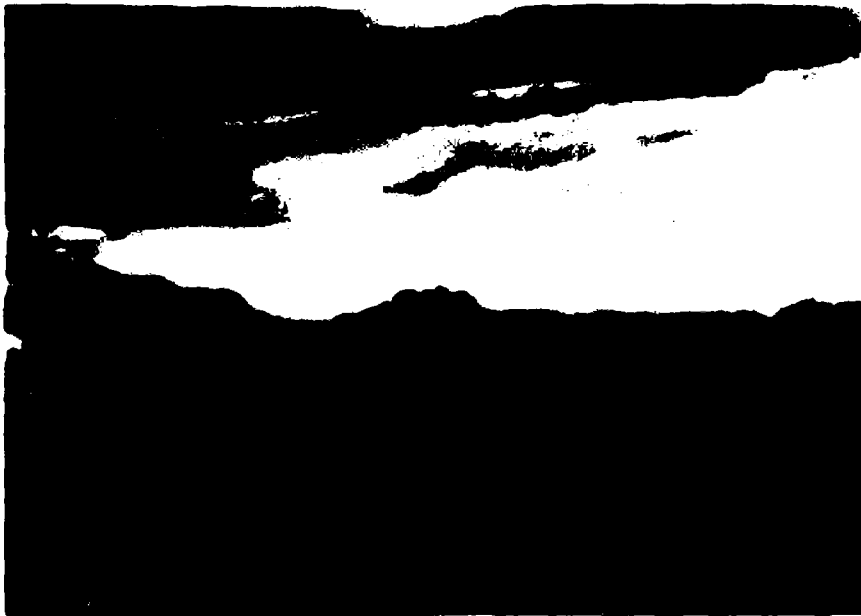


PHOTO 1: CREST OF DAM AT LEFT WING



PHOTO 2: CREST OF DAM AT CENTER SECTION



PHOTO 3: UPSTREAM FACE OF DAM



PHOTO 4: UPSTREAM FACE OF DAM AT LEFT WING



PHOTO 5: UPSTREAM FACE OF DAM



PHOTO 6: DOWNSTREAM FACE OF DAM LOOKING EAST



PHOTO 7: DOWNSTREAM FACE OF DAM LOOKING WEST

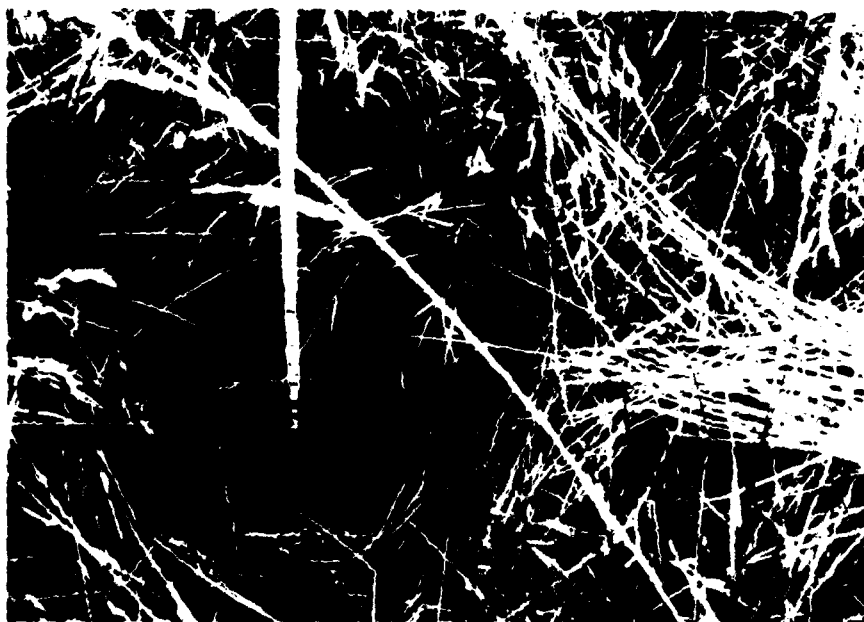


PHOTO 8: PRINCIPAL SPILLWAY INLET



PHOTO 9: EROSION NEAR PRINCIPAL SPILLWAY INLET

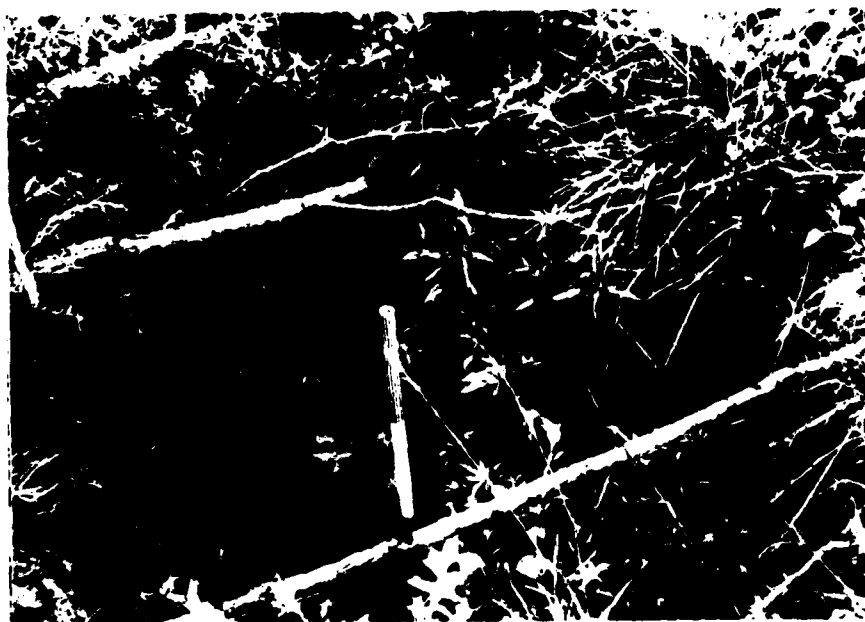


PHOTO 10: EROSION NEAR PRINCIPAL SPILLWAY OUTLET



PHOTO 11: EMERGENCY SPILLWAY LOOKING UPSTREAM



PHOTO 12: EMERGENCY SPILLWAY LOOKING DOWNSTREAM



PHOTO 13: CRACKING ON DAM CREST

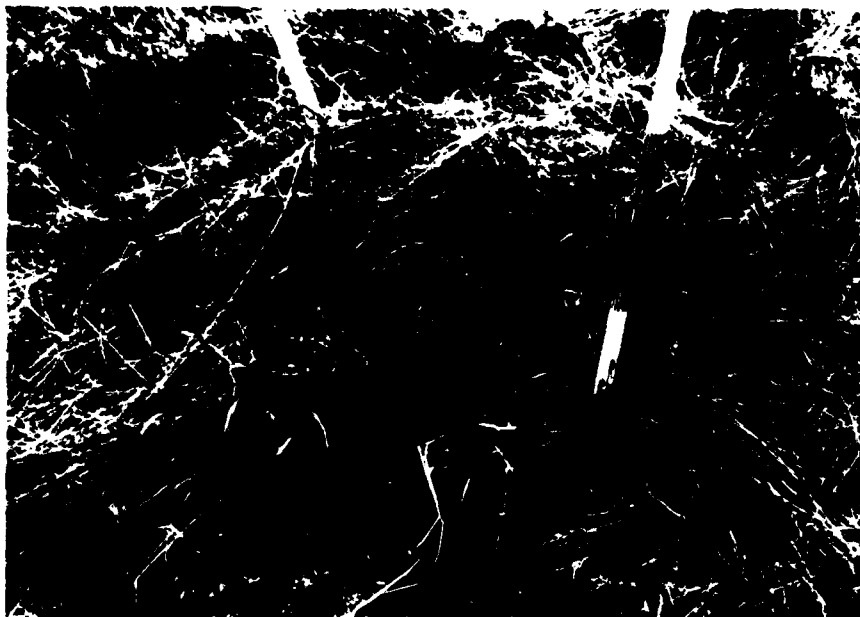


PHOTO 14: ANIMAL BURROW ON DAM CREST

APPENDIX A
HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC ANALYSES

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillways. The overtopping analysis was determined using the computer program HEC-1 (Dam Safety Version) (1).

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33" (HMR-33). Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm was determined according to the procedures outlined in HMR-33 and EM 1110-2-1411. The Kansas City, Missouri rainfall distribution (5 min. interval - 24 hours duration), as provided by the St. Louis District, Corp of Engineers, was used when the one percent chance probability flood was routed through the reservoir and spillways.

The synthetic unit hydrograph for the watershed was developed by the computer program using the Soil Conservation Service (SCS) method. The parameters for the unit hydrograph are shown in Table 1.

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2.

The reservoir routing was performed using the Modified Puls Method. The initial reservoir pool elevation for the routing of each storm was determined to be equivalent to the pipe invert elevation of the principal spillway at elevation 877.6 feet m.s.l. in accordance with antecedent storm conditions preceding the one percent probability and probable maximum storms outlined by the U.S. Army Corps of Engineers, St. Louis District (2). The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation, surface area, storage, and discharge relationships shown in Table 3.

The rating curve for the spillways is shown in Table 4. The flow over the crest of the dam was determined using the non-level dam crest option (\$L and \$V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir. The flow through the principal spillway was determined from nomographs for pipe culverts with inlet control (3). The flow through the emergency spillway was determined using backwater analyses (7).

The result of the routing analyses indicates that 20 percent of the PMP will not overtop the dam.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5.

The computer input data and a summary of the output data are presented at the back of this appendix.

TABLE 1
SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	107 acres
Length of Longest Watercourse (L)	0.33 miles
Elevation Differences in Watershed (H)	30 feet
Wave Velocity (V)	22 feet per second
Length of Reservoir (L_w)	1,400 feet
Lag Time (L_g)	0.13 hours
Time of concentration (T_c)	0.21 hours
Duration (D)	2 min. (use 5 minutes)

<u>Time (Min.) *</u>	<u>Discharge (cfs) *</u>
0	0
5	219
10	480
15	340
20	143
25	65
30	29
35	13
40	6
45	3

* From HEC-1 computer output

FORMULAS USED:

$$T_c = (11.9 \times L^3/H)^{0.385} + V/L_w \quad (4 \text{ and } 5)$$

$$L_g = 0.6 T_c$$

$$D = 0.133 T_c$$

TABLE 2
RAINFALL-RUNOFF VALUES

<u>Selected Storm Event</u>	<u>Storm Duration (Hours)</u>	<u>Rainfall (Inches)</u>	<u>Runoff (Inches)</u>	<u>Loss (Inches)</u>
PMP	24	32.24	31.08	1.16

Additional Data.

- 1) The soil associations in this watershed are Kenoma and Haig (6).
45 percent of drainage area in hydrologic soil group C.
55 percent of drainage area in hydrologic soil group D.
5 percent of the land use was timber.
15 percent of the land use was grassland.
80 percent of the land use was cropland.
- 2) SCS Runoff Curve CN = 91 (AMC III) for the PMF.
- 3) SCS Runoff Curve CN = 80 (AMC II) for the one percent probability flood (5).

TABLE 3
ELEVATION, SURFACE AREA, STORAGE, AND DISCHARGE RELATIONSHIPS

<u>Elevation (feet-MSL)</u>	<u>Lake Surface Area (acres)</u>	<u>Lake Storage (acre-ft)</u>	<u>Spillway Discharge (cfs)</u>
*877.6	21.6	120	0
**878.0	22.6	128	1
***879.2	25.8	157	151

- *Principal spillway pipe invert elevation
**Emergency spillway crest elevation
***Top of dam elevation

The relationships in Table 3 were developed from the East Lynne, Missouri 7.5 minute quadrangle map and the field measurements.

TABLE 4

SPILLWAY RATING CURVE

<u>Reservoir Elevation (ft-msl)</u>	<u>Principal Spillway Discharge (cfs)</u>	<u>Emergency Spillway Discharge (cfs)</u>	<u>Total Spillway Discharges (cfs)</u>
877.6	0	0	0
*878.0	1	0	1
**879.2	1	150	151

*Emergency Spillway Crest Elevation

**Top of Dam Elevation

METHOD USED:

Principal spillway release rates were determined by nomographs for pipe culverts with inlet (3).

Emergency spillway releases were computed by backwater analyses.

TABLE 5

RESULTS OF FLOOD ROUTINGS

<u>Ratio of PMF</u>	<u>Peak Inflow (CFS)</u>	<u>Peak Lake Elevation (ft.-MSL)</u>	<u>Total Storage (AC.-FT.)</u>	<u>Peak Outflow (CFS)</u>	<u>Depth (ft.) Over Top of Dam</u>
-	0	*877.6	120	0	-
0.20	441	879.0	152	100	0
0.50	1,103	879.9	177	462	0.7
1.00	2,206	880.7	200	1,349	1.5

* Principal spillway pipe invert elevation

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- (1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.
- (2) U.S. Army Corps of Engineers, St. Louis District, Hydrologic Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams, 12 December 1979.
- (3) U.S. Department of Commerce, Bureau of Public Roads, Hydraulic Engineering Circular No. 5, Hydraulic Charts for the Selection of Highway Culverts, December, 1965.
- (4) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.
- (5) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.
- (6) U.S. Department of Agriculture, Soil Conservation Service, Preliminary Soil Survey of Cass County, Missouri.
- (7) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Water Surface Profiles (HEC-2), July 1979, Davis, California.
- (8) U.S. Department of Agriculture, Soil Conservation Service, Soil Survey Interpretations and Field Maps, 1980.
- (9) Mary H. McCracken, Missouri Division of Geological Survey, Geologic Map of Missouri, 1961.

MISSOURI DAM INSPECTION PROGRAM
 ST. LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
 BOTH FARMS LAKE DAM

JOB SPECIFICATION

NO	NAME	DAY	JOB	DATE	TIME	TIME	TIME
200		5	0	0	0	0	0
	JOB	5	0	0	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
 MOLAND 1 MOLAND 0 LANTIO 1

BOTH FARMS LAKE (24 MS. PROBABLE MAXIMUM FLOOD)

SUB-AREA SURVEY COMPUTATION

ISTAG	ICOMP	ISCON	ISAGE	ISLT	ISPT	ISAGE	ISAGE	ISAGE
1	0	0	0	0	0	0	0	0

HYDROGRAPH DATA

INTG	TIME	AREA	SOAP	ISDA	ISDC	ISAGE	ISAGE	ISAGE
1	2	.17	.06	.17	1.00	.000	0	0

PRECIP DATA

SPR	WPS	AS	ST	ST	ST	ST	ST
.60	24.00	131.00	120.00	110.00	.00	.60	.60

LOSS DATA

LOOPT	STAGE	STAGE	STAGE	STAGE	STAGE	STAGE	STAGE
0	.00	.00	.00	.00	.00	.00	.00

CURVE NO. = 01.00 WETNESS = 01.00 EFFECT CO. = 01.00

UNIT HYDROGRAPH DATA

STATE	STATE	STATE	STATE	STATE	STATE	STATE	STATE
.00	.00	.00	.00	.00	.00	.00	.00

TIME INTERVAL 100 LAGS--(TIME IS 67.06/2)

UNIT HYDROGRAPH TO TWO OF PROTON OBSERVATIONS. 1.00 .00 MOUNT. LAB. .00 VOL. 1.00
 210. 60. 140. 145. 05. 20. 13. 13.

NO.04	NO.05	PERIOD	BAL.	ECS	LOSS	COMP	NO.04	NO.05	PERIOD	BAL.	ECS	LOSS	COMP	NO.04	NO.05	PERIOD	BAL.	ECS	LOSS	COMP
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1.01	1.01	2	01	00	01	0	1.01	12.10	144	21	20	00	0	1.01	12.10	144	21	20	00	0
1.01	1.01	3	01	00	01	0	1.01	12.15	147	21	20	00	0	1.01	12.15	147	21	20	00	0
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1.01	1.01	5	01	00	01	0	1.01	12.25	149	21	20	00	0	1.01	12.25	149	21	20	00	0
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1.01	7.20	88	-07	-06	71.	1.01	19.20	232	-02	-02	-00	27.
1.01	7.25	89	-07	-06	71.	1.01	19.25	233	-02	-02	-00	27.
1.01	7.30	90	-07	-06	71.	1.01	19.30	234	-02	-02	-00	27.
1.01	7.35	91	-07	-06	71.	1.01	19.35	235	-02	-02	-00	27.
1.01	7.40	92	-07	-06	71.	1.01	19.40	236	-02	-02	-00	27.
1.01	7.45	93	-07	-06	71.	1.01	19.45	237	-02	-02	-00	27.
1.01	7.50	94	-07	-06	71.	1.01	19.50	238	-02	-02	-00	27.
1.01	7.55	95	-07	-06	71.	1.01	19.55	239	-02	-02	-00	27.
1.01	8.00	96	-07	-06	71.	1.01	20.00	240	-02	-02	-00	27.
1.01	8.05	97	-07	-06	71.	1.01	20.05	241	-02	-02	-00	27.
1.01	8.10	98	-07	-06	71.	1.01	20.10	242	-02	-02	-00	27.
1.01	8.15	99	-07	-06	71.	1.01	20.15	243	-02	-02	-00	27.
1.01	8.20	100	-07	-06	71.	1.01	20.20	244	-02	-02	-00	27.
1.01	8.25	101	-07	-06	71.	1.01	20.25	245	-02	-02	-00	27.
1.01	8.30	102	-07	-06	71.	1.01	20.30	246	-02	-02	-00	27.
1.01	8.35	103	-07	-06	71.	1.01	20.35	247	-02	-02	-00	27.
1.01	8.40	104	-07	-06	71.	1.01	20.40	248	-02	-02	-00	27.
1.01	8.45	105	-07	-06	71.	1.01	20.45	249	-02	-02	-00	27.
1.01	8.50	106	-07	-06	71.	1.01	20.50	250	-02	-02	-00	27.
1.01	8.55	107	-07	-06	71.	1.01	20.55	251	-02	-02	-00	27.
1.01	9.00	108	-07	-06	71.	1.01	21.00	252	-02	-02	-00	27.
1.01	9.05	109	-07	-06	71.	1.01	21.05	253	-02	-02	-00	27.

1-01	9-10	110	.07	.56	.00	86.	1-01	21-10	254	.02	.02	.00	27.
1-01	9-15	111	.07	.56 <td>.00<td>86.<td>1-01</td><td>21-15</td><td>255</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>21-15</td><td>255</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>21-15</td> <td>255</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	21-15	255	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	9-20	112	.07	.56 <td>.00<td>86.<td>1-01</td><td>21-20</td><td>256</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>21-20</td><td>256</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>21-20</td> <td>256</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	21-20	256	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	9-25	113	.07	.56 <td>.00<td>86.<td>1-01</td><td>21-25</td><td>257</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>21-25</td><td>257</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>21-25</td> <td>257</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	21-25	257	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	9-30	114	.07	.56 <td>.00<td>86.<td>1-01</td><td>21-30</td><td>258</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>21-30</td><td>258</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>21-30</td> <td>258</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	21-30	258	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	9-35	115	.07	.56 <td>.00<td>86.<td>1-01</td><td>21-35</td><td>259</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>21-35</td><td>259</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>21-35</td> <td>259</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	21-35	259	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	9-40	116	.07	.56 <td>.00<td>86.<td>1-01</td><td>21-40</td><td>260</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>21-40</td><td>260</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>21-40</td> <td>260</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	21-40	260	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	9-45	117	.07	.56 <td>.00<td>86.<td>1-01</td><td>21-45</td><td>261</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>21-45</td><td>261</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>21-45</td> <td>261</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	21-45	261	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	9-50	118	.07	.56 <td>.00<td>86.<td>1-01</td><td>21-50</td><td>262</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>21-50</td><td>262</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>21-50</td> <td>262</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	21-50	262	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	9-55	119	.07	.56 <td>.00<td>86.<td>1-01</td><td>21-55</td><td>263</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>21-55</td><td>263</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>21-55</td> <td>263</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	21-55	263	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	10-00	120	.07	.56 <td>.00<td>86.<td>1-01</td><td>22-00</td><td>264</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>22-00</td><td>264</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>22-00</td> <td>264</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	22-00	264	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	10-05	121	.07	.56 <td>.00<td>86.<td>1-01</td><td>22-05</td><td>265</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>22-05</td><td>265</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>22-05</td> <td>265</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	22-05	265	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	10-10	122	.07	.56 <td>.00<td>86.<td>1-01</td><td>22-10</td><td>266</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>22-10</td><td>266</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>22-10</td> <td>266</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	22-10	266	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	10-15	123	.07	.56 <td>.00<td>86.<td>1-01</td><td>22-15</td><td>267</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>22-15</td><td>267</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>22-15</td> <td>267</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	22-15	267	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	10-20	124	.07	.56 <td>.00<td>86.<td>1-01</td><td>22-20</td><td>268</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>22-20</td><td>268</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>22-20</td> <td>268</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	22-20	268	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	10-25	125	.07	.56 <td>.00<td>86.<td>1-01</td><td>22-25</td><td>269</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>22-25</td><td>269</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>22-25</td> <td>269</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	22-25	269	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	10-30	126	.07	.56 <td>.00<td>86.<td>1-01</td><td>22-30</td><td>270</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>22-30</td><td>270</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>22-30</td> <td>270</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	22-30	270	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	10-35	127	.07	.56 <td>.00<td>86.<td>1-01</td><td>22-35</td><td>271</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>22-35</td><td>271</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>22-35</td> <td>271</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	22-35	271	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	10-40	128	.07	.56 <td>.00<td>86.<td>1-01</td><td>22-40</td><td>272</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>22-40</td><td>272</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>22-40</td> <td>272</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	22-40	272	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	10-45	129	.07	.56 <td>.00<td>86.<td>1-01</td><td>22-45</td><td>273</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>22-45</td><td>273</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>22-45</td> <td>273</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	22-45	273	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	10-50	130	.07	.56 <td>.00<td>86.<td>1-01</td><td>22-50</td><td>274</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>22-50</td><td>274</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>22-50</td> <td>274</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	22-50	274	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	10-55	131	.07	.56 <td>.00<td>86.<td>1-01</td><td>22-55</td><td>275</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>22-55</td><td>275</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>22-55</td> <td>275</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	22-55	275	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	11-00	132	.07	.56 <td>.00<td>86.<td>1-01</td><td>23-00</td><td>276</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>23-00</td><td>276</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>23-00</td> <td>276</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	23-00	276	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	11-05	133	.07	.56 <td>.00<td>86.<td>1-01</td><td>23-05</td><td>277</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>23-05</td><td>277</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>23-05</td> <td>277</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	23-05	277	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	11-10	134	.07	.56 <td>.00<td>86.<td>1-01</td><td>23-10</td><td>278</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>23-10</td><td>278</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>23-10</td> <td>278</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	23-10	278	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	11-15	135	.07	.56 <td>.00<td>86.<td>1-01</td><td>23-15</td><td>279</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>23-15</td><td>279</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>23-15</td> <td>279</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	23-15	279	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	11-20	136	.07	.56 <td>.00<td>86.<td>1-01</td><td>23-20</td><td>280</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>23-20</td><td>280</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>23-20</td> <td>280</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	23-20	280	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	11-25	137	.07	.56 <td>.00<td>86.<td>1-01</td><td>23-25</td><td>281</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>23-25</td><td>281</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>23-25</td> <td>281</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	23-25	281	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	11-30	138	.07	.56 <td>.00<td>86.<td>1-01</td><td>23-30</td><td>282</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>23-30</td><td>282</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>23-30</td> <td>282</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	23-30	282	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	11-35	139	.07	.56 <td>.00<td>86.<td>1-01</td><td>23-35</td><td>283</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>23-35</td><td>283</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>23-35</td> <td>283</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	23-35	283	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	11-40	140	.07	.56 <td>.00<td>86.<td>1-01</td><td>23-40</td><td>284</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>23-40</td><td>284</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>23-40</td> <td>284</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	23-40	284	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	11-45	141	.07	.56 <td>.00<td>86.<td>1-01</td><td>23-45</td><td>285</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>23-45</td><td>285</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>23-45</td> <td>285</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	23-45	285	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	11-50	142	.07	.56 <td>.00<td>86.<td>1-01</td><td>23-50</td><td>286</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>23-50</td><td>286</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>23-50</td> <td>286</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	23-50	286	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	11-55	143	.07	.56 <td>.00<td>86.<td>1-01</td><td>23-55</td><td>287</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-01</td><td>23-55</td><td>287</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-01</td> <td>23-55</td> <td>287</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-01	23-55	287	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
1-01	12-00	144	.07	.56 <td>.00<td>86.<td>1-02</td><td>00</td><td>288</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td></td>	.00 <td>86.<td>1-02</td><td>00</td><td>288</td><td>.02<td>.02<td>.00<td>27.</td></td></td></td></td>	86. <td>1-02</td> <td>00</td> <td>288</td> <td>.02<td>.02<td>.00<td>27.</td></td></td></td>	1-02	00	288	.02 <td>.02<td>.00<td>27.</td></td></td>	.02 <td>.00<td>27.</td></td>	.00 <td>27.</td>	27.
SUM										32.24	31.38	1.76	46363.
										(219.1)	(390.)	(29.)	(1143.52)

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
2206.	447.	140.	140.	49300.
62.	13.	4.	4.	1163.
	44.75	31.24	31.24	31.04
	628.07	288.77	788.37	798.37
	222.	278.	278.	278.
	273.	343.	343.	343.
THOUS CU M	AC-FT	INCHES	MM	CFS

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
110.	22.	7.	7.	2018.
5.	1.	1.	1.	57.
	1.24	1.55	1.55	1.55
	31.43	39.42	39.42	59.42
INCHES	MM	CFS	CM	THOUS CU M

CFS 682. 134. 42. 42. 17106.
 CFS 19. 4. 1. 1. 343.
 INCHES 7.43 9.31 9.31 9.31
 MM 108.60 236.51 236.51 236.51
 AC-FT 66. 83. 83. 83.
 THOUS CU M 82. 103. 103. 103.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 7

PEAK 772. 156. 49. 49. 14126.
 CFS 22. 4. 1. 1. 400.
 CFS 220.03 275.93 275.93 275.93
 INCHES 8.66 10.86 10.86 10.86
 MM 220.03 275.93 275.93 275.93
 AC-FT 78. 97. 97. 97.
 THOUS CU M 96. 120. 120. 120.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 8

PEAK 1103. 223. 70. 70. 20190.
 CFS 31. 6. 2. 2. 571.
 CFS 12.34 15.52 15.52 15.52
 INCHES 314.33 394.19 394.19 394.19
 MM 111. 139. 139. 139.
 AC-FT 137. 171. 171. 171.
 THOUS CU M

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 9

PEAK 2206. 447. 149. 149. 40360.
 CFS 62. 13. 4. 4. 1143.
 CFS 64.75 31.04 31.04 31.04
 INCHES 628.67 788.57 788.57 788.57
 MM 222. 278. 278. 278.
 AC-FT 273. 343. 343. 343.
 THOUS CU M

ROUTE THROUGH SPILLWAY
 HYDROGRAPH ROUTING
 ISTAD ICOMP IECOM ITAPE JPLT JPRT INAME ISTAGE IAUO
 2 1 0 0 0 0 0 0 0 0
 ROUTING DATA

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS															
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9							
				.65	.10	.15	.20	.25	.30	.35	.50	1.00							
HYDROGRAPH AT	1	.17	1	110.	221.	331.	441.	552.	662.	772.	1103.	2294.							
	(.46)	(3.12)	(6.25)	(9.37)	(12.49)	(18.74)	(21.87)	(33.24)	(62.67)	
ROUTED TO	2	.17	1	9.	36.	49.	100.	154.	205.	255.	462.	1369.							
	(.46)	(.25)	(.85)	(1.40)	(2.83)	(4.37)	(5.81)	(7.22)	(13.08)	(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1											
INITIAL VALUE				SPILLWAY CREST				TOP OF DAM			
877.00				877.00				879.25			
120.				120.				137.			
0.				0.				151.			
ELEVATION				MAXIMUM STORAGE				MAXIMUM OUTFLOW			
STORAGE				ACC-FT				CFS			
OUTFLOW				ACC-FT				CFS			
RATIO OF PMF				MINIMUM DEPTH OVER DAM				DURAT ON OVER TOP			
M-S-ELEV				OVER DAM				HOURS			
M-S-ELEV				OVER DAM				HOURS			
M-S-ELEV				OVER DAM				HOURS			
M-S-ELEV				OVER DAM				HOURS			
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